

Claims 47-57 are added.

A clean version of the entire set of pending claims as amended by this Response is presented on the following page.

Clean Version of the Entire Set of Pending Claims

1 1. A DC to DC switching circuit for controlling power
2 switching devices in a DC to DC converter having first and second
3 interleaved converter circuits operating into a common load
4 comprising:

5 a current sense circuit sensing the voltage across a sense
6 resistor in series with the power supply supplying power to the
7 power switching devices;

8 a first pulse width modulator controlling the power
9 switching devices of the first converter circuit;

10 a second pulse width modulator controlling the power
11 switching devices of the second converter circuit;

12 a feedback circuit responsive to the voltage across the
13 common load;

14 control circuits for controlling the first and second pulse
15 width modulators responsive to the feedback circuit and a
16 commanded output voltage;

17 the control circuits also being responsive to the difference
18 in the voltage across the sense resistor when the first converter
19 is drawing power from the power supply through the sense resistor
20 and the second converter is not, and when the second converter is
21 drawing power from the power supply through the sense resistor
22 and the first converter is not, to adjust the relative duty cycle

23 of the first and second converters to tend to minimize the
24 difference in the voltage across the sense resistor;
25 the current sense circuit, the first pulse width modulator,
26 the second pulse width modulator, the feedback circuit and the
27 control circuits being in a single integrated circuit.

1 2. The DC to DC switching circuit of claim 1 wherein the
2 sense resistor is external to the integrated circuit.

1 3. (Amended) The DC to DC switching circuit of claim 1
2 further comprised of an integrator having an output responsive to
3 the integral of an error signal, the error signal being
4 responsive to the voltage across the common load and a desired
5 voltage, the control circuits also being responsive to the output
6 of the integrator.

1 4. The DC to DC switching circuit of claim 3 wherein the
2 time constant of the integrator is adjustable by the selection of
3 at least one component external to the integrated circuit.

1 5. The DC to DC switching circuit of claim 3 further
2 comprised of a differentiator having an output responsive to the
3 rate of change of the voltage across the common load, the control
4 circuits also being responsive to the output of differentiator.

1 6. The DC to DC switching circuit of claim 5 wherein the
2 time constant of the differentiator is adjustable by the
3 selection of at least one component external to the integrated
4 circuit.

1 7. The DC to DC switching circuit of claim 1 wherein the
2 control circuits are also responsive to rapid decreases in the
3 voltage on the common load to turn on the first and second
4 converter circuits independent of the phase of the first and
5 second pulse width modulators.

1 8. The DC to DC switching circuit of claim 7 wherein the
2 control circuits are also responsive to rapid increases in the
3 voltage on the common load to turn off the first and second
4 converter circuits independent of the phase of the first and
5 second pulse width modulators.

1 9. The DC to DC switching circuit of claim 1 further
2 comprised of a load variation circuit coupled to the control
3 circuits to decrease the voltage on the common load for higher
4 voltages across the current sense resistor and to increase the
5 voltage on the common load for lower voltages across the current
6 sense resistor.

1 10. (Amended) DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having first and
3 second converter circuits operating into a common load
4 comprising:
5 a first pulse width modulator controlling the power
6 switching devices of the first converter circuit;
7 a second pulse width modulator controlling the power
8 switching devices of the second converter circuit;
9 a feedback circuit responsive to the voltage across the
10 common load;
11 control circuits for controlling the first and second pulse
12 width modulators responsive to the feedback circuit, the
13 operation of the first and second pulse width modulators being
14 interleaved;
15 the control circuits also being responsive to the difference
16 in current through the first converter and the second converter
17 to adjust the relative duty cycle of the first and second
18 converters to tend to minimize the difference in the voltage
19 across a sense resistor;
20 the first pulse width modulator, the second pulse width
21 modulator, the feedback circuit and the control circuits being in
22 a single integrated circuit.

1 11. The DC to DC switching circuit of claim 10 wherein the
2 commanded output voltage is controllable through an input to the
3 integrated circuit.

1 12. The DC to DC switching circuit of claim 10 wherein the
2 commanded output voltage is controllable through a digital input
3 to the integrated circuit.

1 13. (Amended) The DC to DC switching circuit of claim 12
2 further comprised of an integrator having an output responsive to
3 the integral of an error signal, the error signal being
4 responsive to the voltage across the common load and a desired
5 voltage, the control circuits also being responsive to the output
6 of the integrator.

1 14. The DC to DC switching circuit of claim 13 wherein the
2 time constant of the integrator is adjustable by the selection of
3 at least one component external to the integrated circuit.

1 15. The DC to DC switching circuit of claim 13 further
2 comprised of a differentiator having an output responsive to the
3 rate of change of the voltage across the common load, the control
4 circuits also being responsive to the output of differentiator.

1 16. The DC to DC switching circuit of claim 15 wherein the
2 time constant of the differentiator is adjustable by the
3 selection of at least one component external to the integrated
4 circuit.

1 17. The DC to DC switching circuit of claim 12 wherein the
2 control circuits are also responsive to rapid decreases in the
3 voltage on the common load to turn on the first and second
4 converter circuits independent of the phase of the first and
5 second pulse width modulators.

1 18. The DC to DC switching circuit of claim 17 wherein the
2 control circuits are also responsive to rapid increases in the
3 voltage on the common load to turn off the first and second
4 converter circuits independent of the phase of the first and
5 second pulse width modulators.

1 19. The DC to DC switching circuit of claim 12 further
2 comprised of a load variation circuit coupled to the control
3 circuits to decrease the voltage on the common load for higher
4 currents through the converters and to increase the voltage on
5 the common load for lower currents through the converters.

1 20. The DC to DC switching circuit of claim 12 wherein the
2 commanded output voltage is controllable through an input to the
3 integrated circuit.

1 21. The DC to DC switching circuit of claim 12 wherein the
2 commanded output voltage is controllable through a digital input
3 to the integrated circuit.

1 22. (Amended) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of converter circuits operating into a common load,
4 comprising:

5 a plurality of pulse width modulators driven by a common
6 oscillator in an interleaved manner, each pulse width modulator
7 controlling power switching devices of one of the plurality of
8 converter circuits, whereby the operation of the converter
9 circuits is interleaved;

10 a feedback circuit responsive to a voltage across the common
11 load;

12 a voltage control circuit for controlling the plurality of
13 pulse width modulators responsive to the feedback circuit and a
14 commanded output voltage; and

15 a current balance control circuit for controlling the pulse
16 width modulators to balance the current in the plurality of
17 interleaved converter circuits;

18 the plurality of pulse width modulators and the control
19 circuits being in a single integrated circuit.

1 24. (Amended) The DC to DC switching circuit of claim 22
2 further comprised of an integrator having an output responsive to
3 the integral of an error signal, the error signal being
4 responsive to the voltage across the common load and a desired
5 voltage, the control circuits also being responsive to the output
6 of the integrator.

1 25. The DC to DC switching circuit of claim 24 wherein a
2 time constant of the integrator is adjustable by the selection of
3 at least one component external to the integrated circuit.

1 26. The DC to DC switching circuit of claim 24 further
2 comprised of a differentiator having an output responsive to the
3 rate of change of the voltage across the common load, the control
4 circuits also being responsive to the output of differentiator.

1 27. The DC to DC switching circuit of claim 26 wherein the
2 time constant of the differentiator is adjustable by the

3 selection of at least one component external to the integrated
4 circuit.

1 28. The DC to DC switching circuit of claim 22 wherein the
2 control circuits are also responsive to rapid decreases in the
3 voltage across the common load to turn on the plurality of
4 converter circuits independent of the phase of the plurality of
5 pulse width modulators.

1 29. The DC to DC switching circuit of claim 28 wherein the
2 control circuits are also responsive to rapid increases in the
3 voltage across the common load to turn off the plurality of
4 converter circuits independent of the phase of the plurality of
5 pulse width modulators.

1 30. The DC to DC switching circuit of claim 22, wherein the
2 plurality of pulse width modulators consist of a pair of pulse
3 width modulators.

1 31. The DC to DC switching circuit of claim 22 wherein the
2 feedback circuit is in the single integrated circuit.

1 32. (Amended) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of converter circuits operating into a common load,
4 comprising:

5 a plurality of pulse width modulators each controlling power
6 switching devices of one of the plurality of converter circuits,
7 the operation of the pulse width modulators and the converter
8 circuits being interleaved;

9 a feedback circuit responsive to a voltage across the common
10 load;

11 control circuits being responsive to the feedback circuit
12 and a commanded output voltage to control a nominal duty cycle of
13 the plurality of converter circuits, the control circuits also
14 adjusting a relative duty cycle of the plurality of converter
15 circuits to balance the current in the converter circuits;

16 the plurality of pulse width modulators and the control
17 circuits being in a single integrated circuit.

1 34. (Amended) The DC to DC switching circuit of claim 32
2 wherein the control circuits control the plurality of pulse width
3 modulators.

1 35. The DC to DC switching circuit of claim 32 further
2 comprising: an integrator having an output responsive to the
3 integral of an error signal, the error signal being responsive to
4 the voltage across the common load and a desired voltage.

1 36. (Amended) The DC to DC switching circuit of claim 35,
2 wherein the control circuits are also responsive to the output of
3 the integrator.

1 37. The DC to DC switching circuit of claim 35 wherein a
2 time constant of the integrator is adjustable by the selection of
3 at least one component external to the integrated circuit.

1 38. The DC to DC switching circuit of claim 35 further
2 comprising a differentiator having an output responsive to a rate
3 of change of the voltage across the common load, the control
4 circuits also being responsive to the output of differentiator.

1 39. The DC to DC switching circuit of claim 38 wherein a
2 time constant of the differentiator is adjustable by the
3 selection of at least one component external to the integrated
4 circuit.

1 40. The DC to DC switching circuit of claim 32 wherein the
2 control circuits are also responsive to rapid decreases in the
3 voltage across the common load to turn on the plurality of
4 converter circuits, independent of the phase of the plurality of
5 pulse width modulators.

1 41. The DC to DC switching circuit of claim 32 wherein the
2 control circuits are also responsive to rapid increases in the
3 voltage across the common load to turn off the plurality of
4 converter circuits, independent of the phase of the plurality of
5 pulse width modulators.

1 42. The DC to DC switching circuit of claim 32, wherein the
2 plurality of pulse width modulators consist of a pair of pulse
3 width modulators.

1 43. The DC to DC switching circuit of claim 32 wherein the
2 commanded output voltage is controllable through an input to the
3 integrated circuit.

1 44. The DC to DC switching circuit of claim 32 wherein the
2 feedback circuit is in the single integrated circuit.

1 45. (Amended) A circuit in a DC to DC converter having a
2 plurality of converter circuits operating into a common load,
3 comprising:
4 a plurality of pulse width modulators each controlling power
5 switching devices of one of the plurality of converter circuits,
6 the operation of the pulse width modulators being interleaved;
7 control circuits for adjusting a nominal duty cycle of the
8 plurality of interleaved converter circuits;

9 the plurality of pulse width modulators and the control
10 circuits being in a single integrated circuit.

1 46. A DC to DC switching circuit for controlling power
2 switching devices in a DC to DC converter having first and second
3 interleaved converter circuits operating into a common load,
4 comprising:
5 a first pulse width modulator controlling the power
6 switching devices of the first converter circuit;
7 a second pulse width modulator controlling the power
8 switching devices of the second converter circuit;
9 a feedback circuit responsive to the voltage across the
10 common load;
11 control circuits for controlling the first and second pulse
12 width modulators responsive to the feedback circuit;
13 the control circuits also being responsive to current
14 measurements through the first converter circuit and the second
15 converter circuit for adjusting the relative duty cycle of the
16 first and second converter circuits;
17 the first pulse width modulator, the second pulse width
18 modulator, the feedback circuit and the control circuits being in
19 a single integrated circuit.

1 47. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a

3 plurality of converter circuits operating into a common load,
4 comprising:

5 a plurality of pulse width modulators driven by a common
6 oscillator in an interleaved manner, each pulse width modulator
7 controlling power switching devices of one of the plurality of
8 converter circuits, whereby the operation of the converter
9 circuits is interleaved;

10 a feedback circuit responsive to a voltage across the common
11 load;

12 a voltage control circuit for controlling the plurality of
13 pulse width modulators responsive to the feedback circuit and a
14 commanded output voltage; and

15 a current balance control circuit for controlling the pulse
16 width modulators to balance the current in the plurality of
17 interleaved converter circuits.

1 48. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of converter circuits operating into a common load,
4 comprising:

5 a plurality of pulse width modulators each controlling power
6 switching devices of one of the plurality of interleaved
7 converter circuits, the operation of the pulse width modulators
8 and the converter circuits being interleaved;

9 a feedback circuit responsive to a voltage across the common
10 load;

11 control circuits responsive to the feedback circuit and a
12 commanded output voltage to control a nominal duty cycle of the
13 plurality of converter circuits, the control circuits also
14 adjusting a relative duty cycle of the plurality of converter
15 circuits to balance the current in the converter circuits.

1 49. (New) A circuit for a DC to DC converter having a
2 plurality of converter circuits operating into a common load,
3 comprising:

4 a plurality of pulse width modulators each controlling power
5 switching devices of one of the plurality of converter circuits,
6 the pulse width modulators being driven by a common oscillator
7 signal so that the operation of the pulse width modulators is
8 interleaved;

9 control circuits for adjusting a nominal duty cycle of the
10 plurality of interleaved converter circuits to control a voltage
11 on the common load, and for adjusting a relative duty cycle of
12 the plurality of converter circuits to balance the current in the
13 converter circuits.

1 50. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having first and

3 second interleaved converter circuits operating into a common
4 load, comprising:
5 a first pulse width modulator controlling the power
6 switching devices of the first converter circuit;
7 a second pulse width modulator controlling the power
8 switching devices of the second converter circuit;
9 a feedback circuit responsive to the voltage across the
10 common load;
11 control circuits for controlling the first and second pulse
12 width modulators responsive to the feedback circuit;
13 the control circuits also being responsive to current
14 measurements through the first converter circuit and the second
15 converter circuit for adjusting the relative duty cycle of the
16 first and second converter circuits.

1 51. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of buck converter circuits operating into a common
4 load, comprising:
5 a plurality of pulse width modulators driven by a common
6 oscillator in an interleaved manner, each pulse width modulator
7 controlling power switching devices of one of the plurality of
8 buck converter circuits, whereby the operation of the buck
9 converter circuits is interleaved;

10 a feedback circuit responsive to a voltage across the common
11 load;

12 a voltage control circuit for controlling the plurality of
13 pulse width modulators responsive to the feedback circuit and a
14 commanded output voltage; and

15 a current balance control circuit for controlling the pulse
16 width modulators to balance the current in the plurality of
17 interleaved buck converter circuits;

18 the plurality of pulse width modulators and the control
19 circuits being in a single integrated circuit.

1 52. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of buck converter circuits operating into a common
4 load, comprising:

5 a plurality of pulse width modulators each controlling power
6 switching devices of one of the plurality of buck converter
7 circuits, the operation of the pulse width modulators and the
8 buck converter circuits being interleaved;

9 a feedback circuit responsive to a voltage across the common
10 load;

11 control circuits being responsive to the feedback circuit
12 and a commanded output voltage to control a nominal duty cycle of
13 the plurality of buck converter circuits, the control circuits
14 also adjusting a relative duty cycle of the plurality of buck

15 converter circuits to balance the current in the buck converter
16 circuits;

17 the plurality of pulse width modulators and the control
18 circuits being in a single integrated circuit.

1 53. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having first and
3 second interleaved buck converter circuits operating into a
4 common load, comprising:

5 a first pulse width modulator controlling the power
6 switching devices of the first buck converter circuit;

7 a second pulse width modulator controlling the power
8 switching devices of the second buck converter circuit;

9 a feedback circuit responsive to the voltage across the
10 common load;

11 control circuits for controlling the first and second pulse
12 width modulators responsive to the feedback circuit;

13 the control circuits also being responsive to current
14 measurements through the first buck converter circuit and the
15 second buck converter circuit for adjusting the relative duty
16 cycle of the first and second buck converter circuits;

17 the first pulse width modulator, the second pulse width
18 modulator, the feedback circuit and the control circuits being in
19 a single integrated circuit.

1 54. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of buck converter circuits operating into a common
4 load, comprising:

5 a plurality of pulse width modulators driven by a common
6 oscillator in an interleaved manner, each pulse width modulator
7 controlling power switching devices of one of the plurality of
8 buck converter circuits, whereby the operation of the buck
9 converter circuits is interleaved;

10 a feedback circuit responsive to a voltage across the common
11 load;

12 a voltage control circuit for controlling the plurality of
13 pulse width modulators responsive to the feedback circuit and a
14 commanded output voltage; and

15 a current balance control circuit for controlling the pulse
16 width modulators to balance the current in the plurality of
17 interleaved buck converter circuits.

1 55. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having a
3 plurality of buck converter circuits operating into a common
4 load, comprising:

5 a plurality of pulse width modulators each controlling power
6 switching devices of one of the plurality of interleaved buck

7 converter circuits, the operation of the pulse width modulators
8 and the buck converter circuits being interleaved;

9 a feedback circuit responsive to a voltage across the common
10 load;

11 control circuits responsive to the feedback circuit and a
12 commanded output voltage to control a nominal duty cycle of the
13 plurality of buck converter circuits, the control circuits also
14 adjusting a relative duty cycle of the plurality of buck
15 converter circuits to balance the current in the buck converter
16 circuits.

1 56. (New) A circuit for a DC to DC converter having a
2 plurality of buck converter circuits operating into a common
3 load, comprising:

4 a plurality of pulse width modulators each controlling power
5 switching devices of one of the plurality of buck converter
6 circuits, the pulse width modulators being driven by a common
7 oscillator signal so that the operation of the pulse width
8 modulators is interleaved;

9 control circuits for adjusting a nominal duty cycle of the
10 plurality of interleaved buck converter circuits to control a
11 voltage on the common load, and for adjusting a relative duty
12 cycle of the plurality of buck converter circuits to balance the
13 current in the converter circuits.

1 57. (New) A DC to DC switching circuit for controlling
2 power switching devices in a DC to DC converter having first and
3 second interleaved buck converter circuits operating into a
4 common load, comprising:
5 a first pulse width modulator controlling the power
6 switching devices of the first buck converter circuit;
7 a second pulse width modulator controlling the power
8 switching devices of the second buck converter circuit;
9 a feedback circuit responsive to the voltage across the
10 common load;
11 control circuits for controlling the first and second pulse
12 width modulators responsive to the feedback circuit;
13 the control circuits also being responsive to current
14 measurements through the first buck converter circuit and the
15 second buck converter circuit for adjusting the relative duty
16 cycle of the first and second buck converter circuits.